

Expanded EPAAct Program

EPA/DOE Collaboration

January 8, 2008

Base EPAct Program

Base EPAAct Program

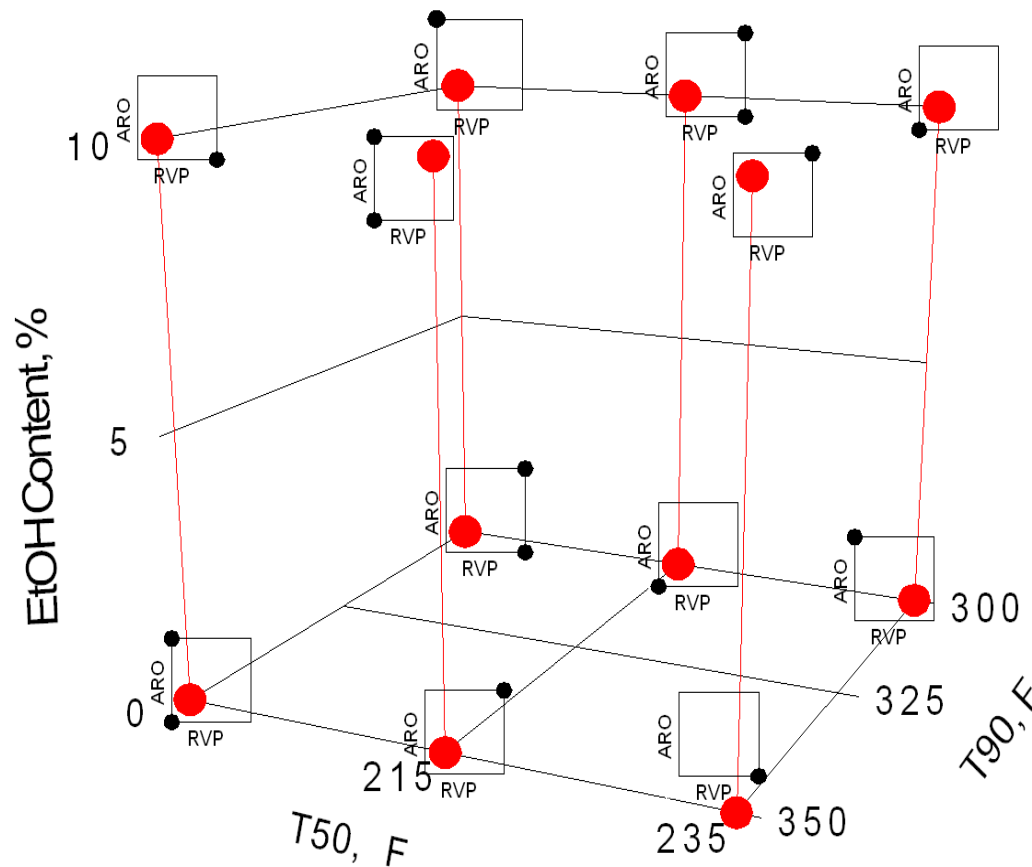
- Objective: Establish effects of RVP,T50,T90, aromatic content and EtOH on exhaust emissions from Tier 2 vehicles
- 16 fuels, 19 vehicles in main program
- “GHG Pilot” to precede main program
 - E0, E10, E15 fuels tested in all 19 vehicles at 75°F and 50°F
 - Test results to feed into RFS 2 NPRM
- Parameters measured: Regulated emissions, CO₂, NO₂, VOCs, ethanol, carbonyls
 - Also N₂O, NH₃ and HCN by FTIR
 - No PM speciation

5 U.S.C. § 552(b)(5) Deliberative

Base Fuel Matrix

5 variables, 3x2x2x2x2, 16 fuels (+3 GHG fuels)

RVP range: 7-9 psi; Aromatic content range: 15 – 40%



Base Fuel Matrix (Cont'd)

- Computer generated optimal design
- Fuel variables:
 - T50 (3 levels)
 - T90 (2 levels)
 - EtOH (2 levels)
 - RVP (2 levels)
 - Aromatics (2 levels)
- Terms in model: Main effects, $T50^2$, $T50 \cdot EtOH$, $T90 \cdot EtOH$, $RVP \cdot EtOH$, $aromatics \cdot EtOH$
- Number of test fuels: 16 (+3 GHG fuels)
- G-Efficiency: 83.6%

Base Fuel Matrix (Cont'd)

PROPERTY	UNIT	METHOD	BLENDING TOLERANCE	TEST FUELS									
				1	2	3	4	5	6	7	8	9	10
Relative Density, 60/60°F	-	D4052	NA	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
API Gravity, 60°F	°API	D4052	NA	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
Ethanol Content	vol. %	D5599	E0: < 0.1; E10: ± 0.5; E15: ± 0.5; E20: ±0.5; E85: ±2	0	0	10	0	0	10	0	10	10	0
Total Content of Oxygenates Other than Ethanol	vol. %	D5599	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
T10	°F	D86	± 10	140	140	140	140	140	140	140	140	140	140
T50	°F	D86	± 4	195	195	195	195	195	195	215	215	215	215
T90	°F	D86	± 5	300	300	300	350	350	350	300	300	300	350
FBP	°F	D86	-	<437	<437	<437	<437	<437	<437	<437	<437	<437	<437
DVPE	psi	D5191	± 0.15	9.0	9.0	6.65	6.65	6.65	9.0	6.65	9.0	9.0	9.0
Aromatics	vol. %	D1319	± 1.5	15	40	40	15	40	15	15	15	40	40
Olefins	vol. %	D1319	± 1.5	7	7	7	7	7	7	7	7	7	7
Benzene	vol. %	D3606	± 0.15	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
S	mg/kg	D5453	± 5	25	25	25	25	25	25	25	25	25	25
RON	-	D2699	± 2	93	93	93	93	93	93	93	93	93	93
MON	-	D2700	± 2	85	85	85	85	85	85	85	85	85	85
(R + M)/2	-	Calc.	± 2	89	89	89	89	89	89	89	89	89	89
C	mass %	Calc.	-	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
H	mass %	D4808 Method A	-	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
O	mass %	D5599	-	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
Water Content	mg/kg	E1064	-	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
Net Heat of Combustion	MJ/kg	D4809	-	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
Oxidation Stability	minute	D525	-	>240	>240	>240	>240	>240	>240	>240	>240	>240	>240
Copper Strip Corrosion, 3h at 122°F	-	D130	-	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1
Solvent-Washed Gum Content	mg/100 ml	D381	-	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5

Base Fuel Matrix (Cont'd)

TEST FUELS								
11	12	13	14	15	16	17	18	19
Report	Report	Report	Report	Report	Report	Report	Report	Report
Report	Report	Report	Report	Report	Report	Report	Report	Report
10	10	0	10	0	10	0	9.5	14.5
<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.15
140	140	140	140	140	140	140	140	140
215	215	235	235	235	235	215	202	195
350	350	300	300	350	350	325	325	325
<437	<437	<437	<437	<437	<437	<437	<437	<437
6.65	6.65	6.65	6.65	9.0	9.0	8.85	8.85	8.85
40	15	40	15	15	40	29.5	24.9	22.6
7	7	7	7	7	7	7	7	7
0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
25	25	25	25	25	25	25	25	25
93	93	93	93	93	93	93	93	93
85	85	85	85	85	85	85	85	85
89	89	89	89	89	89	89	89	89
Report	Report	Report	Report	Report	Report	Report	Report	Report
Report	Report	Report	Report	Report	Report	Report	Report	Report
Report	Report	Report	Report	Report	Report	<0.1	Report	Report
Report	Report	Report	Report	Report	Report	Report	Report	Report
Report	Report	Report	Report	Report	Report	Report	Report	Report
>240	>240	>240	>240	>240	>240	>240	>240	>240
<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1
< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5

Vehicle Fleet Sizing

- Based on risk analysis
 - Same type of analysis was used in AutoOil Program
- Depends on assumed emissions difference which should be readily detectable as significant
- Requires estimates of the following parameters:
 - Test-to-test variability
 - Vehicle-to-vehicle variability among vehicles of the same model
- Internal EPA and OEM round robin lab correlation test data was used to determine fleet size
- Resultant EPACT Program fleet size: 19 vehicles

Vehicle Selection

- Based on MY engine family sales data
 - Usually multiple models to choose from for each engine family
 - High volume sellers are, by definition, representative, and should ease recruitment
- Data available for MY 04 – 06 Tier 2 vehicles
- All test vehicles must be Tier 2 (Bin 5 fleet average)
- All vehicles will be new and leased

Proposed Test Vehicles

Make	Year	Brand	Model	Engine	Family	T2 Bin
GM	2007	Chevrolet	Cobalt/HHR	2.4L I4	7GMXV02.4029	5
GM	2007	Chevrolet	Impala	3.5L V6	7GMXV03.5052	5
GM	2007	Buick/GMC/Saturn	Enclave/Acadia/Outlook	3.6L V6	7GMXT03.6151	5
GM	2007	Chevrolet/GMC	Avalanche	5.3L V8	7GMXT05.3381	4
Toyota	2007	Toyota	Corolla	1.8L I4	7TYXV01.8BEA	5
Toyota	2007	Toyota	Camry	2.4L I4	7TYXV02.4BEB	5
Toyota	2007	Toyota	Sienna	3.3L V6	7TYXT03.3BEM	5
Toyota	2007	Toyota	Tundra	4.0L V6	7TYXT04.0AEV	5
Ford	2007	Ford	Focus	2.0L I4	7FMXV02.0VD4	4
Ford	2007	Ford	500/new Taurus/Freestyle	3.0L V6	7FMXV03.0VED	5
Ford	2007	Ford/Mercury	Explorer/Mountaineer	4.0L V6	7FMXT04.03DB	4
Ford	2007	Ford	F150	5.4L V8	7FMXT05.44H2	8
Chrysler	2007	Dodge	Caliber	2.4L I4	7CRXB0144M80	5
Chrysler	2007	Dodge/Chrysler	Caravan/Town & Country	3.3L V6	7CRXT03.3NHP	8
Chrysler	2007	Jeep	Liberty	3.7L V6	7CRXT03.7NE0	5
Honda	2007	Honda	Civic	1.8L I4	7HNXV01.8MKR	5
Honda	2007	Honda	Accord	2.4L I4	7HNXV02.4KKC	5
Honda	2007	Honda	Odyssey	3.5L V6	7HNXT03.5VKR	5
Nissan	2007	Nissan	Altima	2.5L I4	7NSXV02.5G5A	5

Test Program

- Consists of three phases:
 - Phase 1: GHG Pilot at 75°F
 - E0, E10, E15; 19 vehicles
 - Phase 2: GHG Pilot at 50°F
 - E0, E10, E15; 19 vehicles
 - Phase 3: Main Program
 - 19 fuels, 19 vehicles
- California Unified Cycle (LA92) will be used throughout the program
- The order in which the various fuel/vehicle combinations are to be tested will be randomized
 - However, replicate tests will be done back-to-back
- The third replicate will be run if test-to-test ratio of NO_x, HC or CO₂ results exceeds threshold value
 - Threshold values defined per methodology used in AutoOil program

Measured Parameters

- Bag (phase) level and composite emissions of THC, NMHC, NMOG, CO, CO₂, NO_x, NO₂, ethanol and PM
- Bag (phase) level speciated volatile organic compounds (VOCs)
 - Over 200 compounds, incl. alcohols and carbonyls
- Continuous and integrated by bag (phase) emissions of the following species in raw exhaust:
 - THC, NMHC, CO, CO₂, NO_x,
 - N₂O, NH₃ and HCN by FTIR for a subset of tests

Expanded EPO Act Program

Expanded EPAAct Program

- \$0.9M has been made available to NREL from DOE's Biomass Program for use in expanding the EPAAct Program
 - NREL has already received a funding letter from DOE for this amount
- Additional \$1.1M is expected to become available shortly from DOE's Vehicle Technology Program
- Expanded fuel matrix consists of the following 29 fuels:
 - Base fuel matrix (16 + 3 fuels)
 - Includes the same fuels as Base EPAAct Program
 - 9 additional E15 and E20 fuels and one E85 fuel per prior discussions with DOE
- DOE expressed interest in testing additional vehicles
- Lubrizol has committed to provide lubricant support for this program

Expanded EPA Act Program (Cont'd)

- Further timeline and cost estimates assume the following:
 - 3 additional vehicles used in Phases 1, 2 and 3 of the program
 - Test program design similar to Base EPA Act Program
 - Phase 1: GHG Pilot at 75°F
 - E0, E10, E15; 22 vehicles
 - Phase 2: GHG Pilot at 50°F
 - E0, E10, E15; 22 vehicles
 - Phase 3: Main Program
 - 25 fuels, 22 vehicles
 - One E85 fuel tested in four FFVs
 - Same parameters measured
- The add-on cost of the DOE component is estimated at \$2.0M
- Expanded Program Timeline, w/o safety margin
 - Jan. 2008 – May 2008: Fuel blending
 - April 2008 – April 2009: Emissions testing
 - May 2009 – July 2009: Reporting

Expanded Fuel Matrix

Fuel #	T50	T90	ETOH	RVP	ARO
	°F	°F	%	psi	%
1	235	300	10	7	15
2	235	350	0	9	15
3	195	350	10	9	15
4	195	350	0	7	40
5	195	300	10	7	40
6	235	300	0	7	40
7	215	350	10	7	15
8	215	300	10	9	15
9	215	350	0	9	40
10	215	300	0	7	15
11	215	300	10	9	40
12	215	350	10	7	40
13	195	350	0	7	15
14	195	300	0	9	15
15	235	350	10	9	40
16	195	300	0	9	40
17	215	325	0	9	30
18	202	325	10	9	25
19	195	325	15	9	23
20	160	300	20	7	15
21	168.2	300	15.3	7	15
22	160	350	20	7	40
23	160	300	20	9	40
24	160	350	20	9	15
25	195	300	15.3	7	15
26	168.2	350	15.3	9	40
27	195	350	15.3	9	40
28	160	350	20	9	40
29	TBD	TBD	85	TBD	TBD

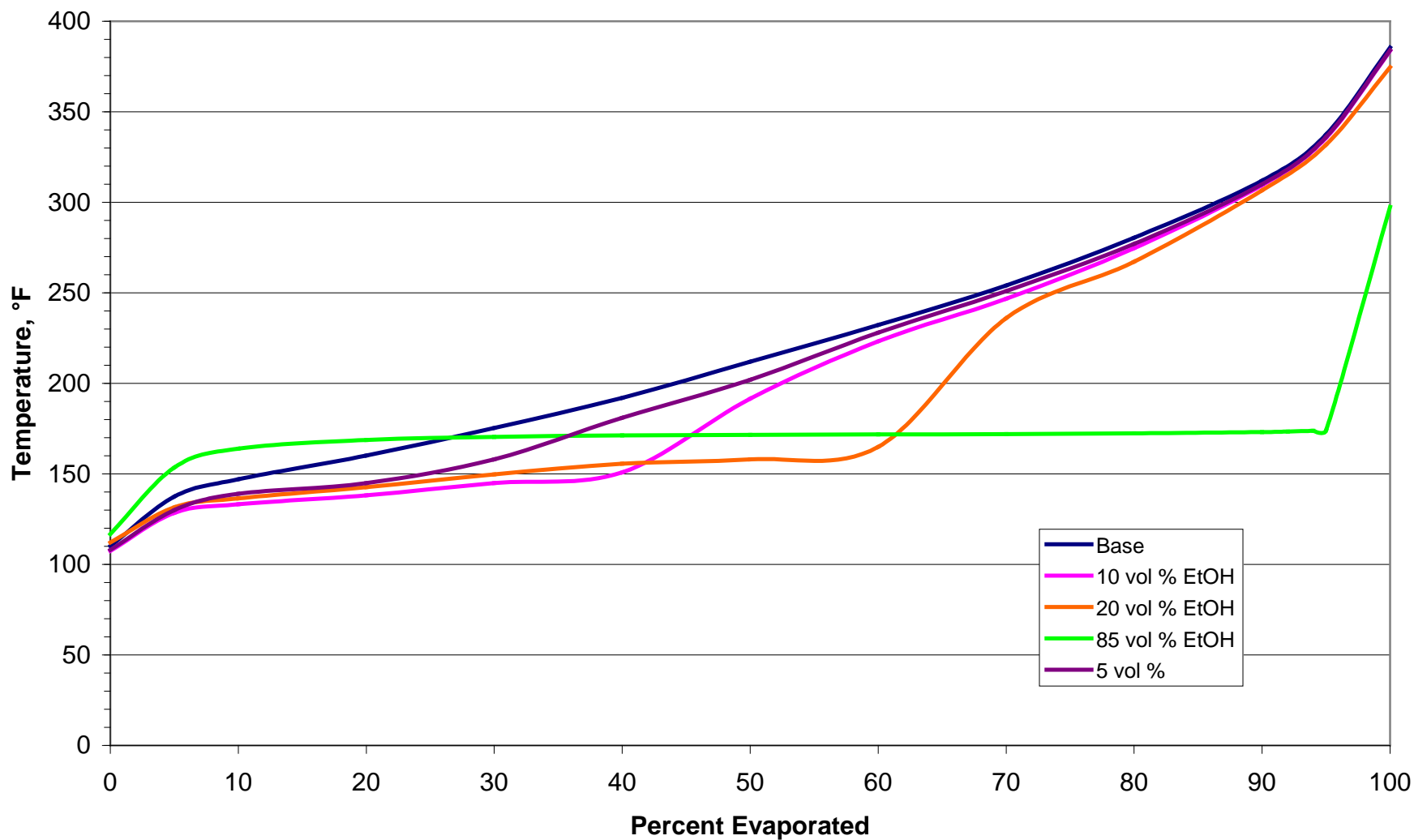
Base Matrix
(1-16)

GHG Subset
(17-19)

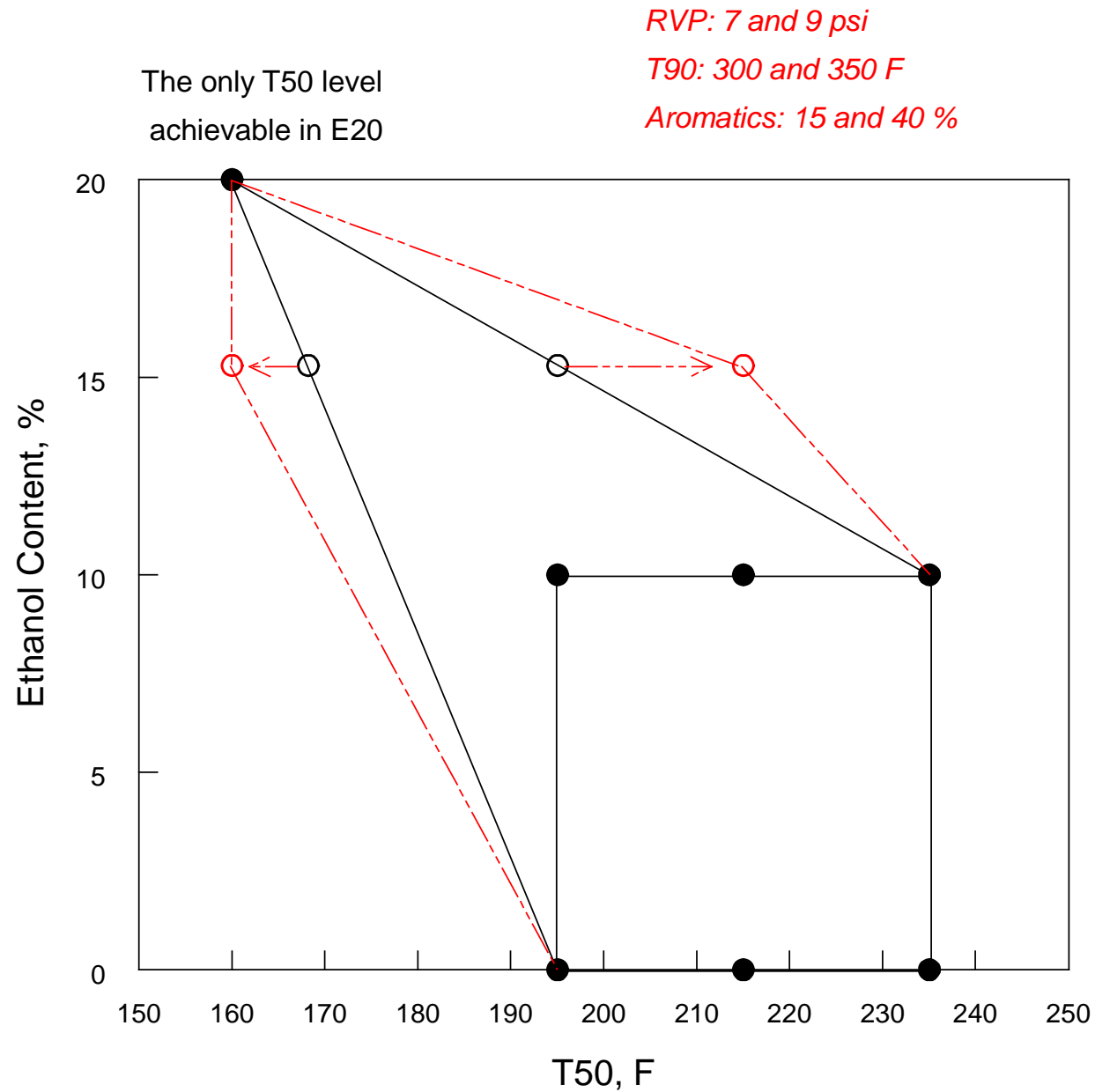
DOE Fuels
(20-29)

E85

Effect of Ethanol Addition on the D 86 Distillation Curve



Source: Chevron



Main (Phase 3) Fuel Matrix

- Computer generated optimal design
- Fuel variables:
 - T50 (3 levels)
 - T90 (2 levels)
 - EtOH (4 levels)
 - RVP (2 levels)
 - Aromatics (2 levels)
- Terms in model: Main effects, EtOH^2 , T50^2 , $\text{T50} \times \text{EtOH}$, $\text{T90} \times \text{EtOH}$, $\text{RVP} \times \text{EtOH}$, $\text{aromatics} \times \text{EtOH}$
- Number of test fuels: 25
- G-Efficiency: 70.1%
- T50 range of E15 fuels must be confirmed by Halterman

Base Fuel Matrix (Cont'd)

PROPERTY	UNIT	METHOD	BLENDING TOLERANCE	TEST FUELS									
				1	2	3	4	5	6	7	8	9	10
Relative Density, 60/60°F	-	D4052	NA	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
API Gravity, 60°F	°API	D4052	NA	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
Ethanol Content	vol. %	D5599	E0: < 0.1; E10: ± 0.5; E15: ± 0.5; E20: ±0.5; E85: ±2	0	0	10	0	0	10	0	10	10	0
Total Content of Oxygenates Other than Ethanol	vol. %	D5599	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
T10	°F	D86	± 10	140	140	140	140	140	140	140	140	140	140
T50	°F	D86	± 4	195	195	195	195	195	195	215	215	215	215
T90	°F	D86	± 5	300	300	300	350	350	350	300	300	300	350
FBP	°F	D86	-	<437	<437	<437	<437	<437	<437	<437	<437	<437	<437
DVPE	psi	D5191	± 0.15	9.0	9.0	6.65	6.65	6.65	9.0	6.65	9.0	9.0	9.0
Aromatics	vol. %	D1319	± 1.5	15	40	40	15	40	15	15	15	40	40
Olefins	vol. %	D1319	± 1.5	7	7	7	7	7	7	7	7	7	7
Benzene	vol. %	D3606	± 0.15	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
S	mg/kg	D5453	± 5	25	25	25	25	25	25	25	25	25	25
RON	-	D2699	± 2	93	93	93	93	93	93	93	93	93	93
MON	-	D2700	± 2	85	85	85	85	85	85	85	85	85	85
(R + M)/2	-	Calc.	± 2	89	89	89	89	89	89	89	89	89	89
C	mass %	Calc.	-	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
H	mass %	D4808 Method A	-	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
O	mass %	D5599	-	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
Water Content	mg/kg	E1064	-	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
Net Heat of Combustion	MJ/kg	D4809	-	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
Oxidation Stability	minute	D525	-	>240	>240	>240	>240	>240	>240	>240	>240	>240	>240
Copper Strip Corrosion, 3h at 122°F	-	D130	-	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1
Solvent-Washed Gum Content	mg/100 ml	D381	-	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5

Base Fuel Matrix (Cont'd)

TEST FUELS																		
11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29*
Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
10	10	0	10	0	10	0	9.5	14.5	20	15.3	20	20	20	15.3	15.3	15.3	20	81
<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.15	<0.2	<0.15	<0.2	<0.2	<0.2	<0.15	<0.15	<0.15	<0.2	<2.0
140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	-
215	215	235	235	235	235	215	202	195	160	168	160	160	160	195	168	195	160	-
350	350	300	300	350	350	325	325	325	300	300	350	300	350	300	350	350	350	-
<437	<437	<437	<437	<437	<437	<437	<437	<437	<437	<437	<437	<437	<437	<437	<437	<437	<437	-
6.65	6.65	6.65	6.65	9.0	9.0	8.85	8.85	8.85	6.65	6.65	6.65	9.0	9.0	6.65	9.0	9.0	9.0	6.85
40	15	40	15	15	40	29.5	24.9	22.6	15	15	40	40	15	15	40	40	40	Report
7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	Report
0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	Report
25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	15
93	93	93	93	93	93	93	93	93	93	93	93	93	93	93	93	93	93	Report
85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	Report
89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	Report
Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
Report	Report	Report	Report	Report	Report	<0.1	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	<10,000
Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report	Report
>240	>240	>240	>240	>240	>240	>240	>240	>240	>240	>240	>240	>240	>240	>240	>240	>240	>240	-
<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	<No. 1	-
< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5

Timeline of Expanded EPA Act Program

Phase	# of Emission Tests	# of Weeks	Duration	
			From	To
Fuel blending	-	22	2-Jan	31-May
Phase 1 (75°F)	135	5	1-Apr	6-May
50°F Switchover	-	2	7-May	20-May
Phase 2 (50°F)	135	7.5	21-May	11-Jul
Phase 3 (75°F)	1128	41.8	14-Jul	30-Apr-09
Reporting	-	12	1-May-09	31-Jul-09

No margin of safety !!!

5 U.S.C. § 552(b)(5) Deliberative

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Next Steps

- Finalize the design of the expanded EPAAct Program
- Define options to pursue in case additional funds become available
- Coordinate with SWRI and Halterman to make sure that test fuels are blended on time
- Coordinate with SWRI to make sure that the test program is launched on time and each of its three phases completed according to schedule
- Set up a joint EPA/NREL program oversight system to ensure that test data generated is of required quality